EFFECTS OF DIETARY CRUDE PROTEIN LEVELS AND CEREAL STOVER AND BUFFEL GRASS HAY BASED TOTAL MIXED RATIONS ON INTAKE AND GROWTH PERFORMANCE OF YEARLING TSWANA SHEEP

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ABSTRACT

The study was conducted to find out the effects of crude protein (CP) levels (13.5 %, 15.5 % and 17.5 %) and different forages (sorghum stover, millet stover and buffel grass hay) on feed intake, growth rate and feed efficiency of Tswana yearling sheep. Fifty-four (54) sheep castrates were allocated to treatments in 3 x 3 factorial arrangements under completely randomised design for ninety days. It was found that crude protein level influenced (P < 0.05) total feed intake, final live weight, average daily gain and feed efficiency. Crude protein levels of 13.5 % and 15.5 % produced statistically (P < 0.05) similar final weights. The final weight and average daily gain (ADG) decreased linearly with increasing levels of dietary protein. Diets containing 13.5 % CP produced the highest mean total feed intake, ADG and feed efficiency, while the highest CP (17.5 %) produced the lowest total feed intake and daily gain. Forage type significantly influenced final live-weights, ADG and feed intake in yearling sheep. Millet stover rations produced higher (P<0.05) live weight, ADG and feed intake in yearling sheep than the other two diets. On the other hand, sorghum stover based rations produced the lowest live weight, ADG and total feed intake. Yearling Tswana sheep may be fed millet and sorghum stovers and buffel grass hay based TMR containing 13.5 % CP since with this level of crude protein sheep gave superior performances in all parameters assessed. Given the relative performance of the three diets, it is recommended that millet stover based diets be fed as the first choice, followed by buffel grass and sorghum based diets in that order depending on availability.

Keywords: Forage type, dietary crude protein level, Total Mixed Rations, Growth Performance, yearling Tswana sheep

INTRODUCTION

When compared to other domestic ruminants, sheep are the least kept (293,966 sheep) among Botswana farmers (Statistics Botswana, 2014) and a majority of them are reported by Nsoso *et al.* (2006) to be indigenous (Tswana breed). Even though the population of sheep in Botswana is small, their role in the cultural and religious ceremonies as well as economic activities locally is increasing. It is generally observed that local smallstock farmers trade more in yearling sheep than weaners because they produce superior carcass yields and bring higher profits. In addition, yearling sheep are more likely to fatten within a shorter period than sheep weaners. Intensifying fattening of yearling sheep to respond to the demand for sheep and its products may require increased production of good quality feeds locally. However, growing the best fodder crops like lucerne on a large is a challenge in Botswana because of the high water requirements for such crops. Therefore, there is a great need to find alternate feed resources that would do well under low rainfall conditions. There is a preponderance of crop residues from sorghum, millet and maize in Botswana at harvest time. However, anecdotal evidence suggests that very small amount of this cereal stover is utilized as animal feed. The major proportion of the cereal crop residues is wasted. Although various researchers (Sialapwa and Simukoko, 2004; Sultan *et al*., 2009; Singh et al., 2011; Mthetho *et al*., 2015) have identified crop residues as potential alternate feed. Very few local farmers utilize crop residues in feed formulations. They commonly provide them to animals as sole diet without being processed and supplemented, and this practice has resulted in suboptimal performance in animals.

Low performance of ruminants solely fed on cereal stover is attributed to low ruminal fermentation caused by deficiency in fermentable carbohydrates and low protein content in these crop residues (Sultan *et al*, 2009). Supplementing cereal stovers with good quality sources of protein and fermentable carbohydrates has the potential to encourage optimal rumen fermentation, improve feed intake and weight gains (Sibanda, 1986; Aganga and Nsinamwa. 1997 and Koralagama *et al*., 2008). While the nutritive value of feed supplements may have a significant role in improving the digestibility of the ruminant diet, their

availability and affordability have the potential to stimulate utilization of cereal stovers in smallholder farming.

Sunflower seed cake is a good protein supplement to ruminants (Aganga and Nsinamwa, 1997; Jabbar *et al*., 2006) while cereal grain products like sorghum bran contain high fermentable carbohydrates. However, there is inadequate information on effects of cereal crop residues and these agro-industrial by-products when fed as total mixed rations (TMR) on feed intake and liveweight gain of Tswana sheep. Therefore, it is important to develop feeding strategies using common agro-industrial by-products to improve utilization of cereal crop residues in local sheep farming. In addition, the best local cereal stovers that promote high daily gains in sheep need to be identified so that smallholder sheep farmers may adopt these.

Feeding Tswana sheep based on their crude protein requirement is challenge due to lack of developed feeding standard specifically for this breed. This has resulted in most local animal nutrition researches using information from National Research Council (NRC) and Agriculture Research Council (ARC) when formulating rations for these native breed. This practice may not represent the crude protein requirement of Tswana sheep breed because of differences in breed, environmental factors, age and feed quality (NRC, 1985). This information gap with regard to optimum crude protein level required for fattening Tswana sheep yearlings made this study appropriate. The study was aimed at finding out optimum dietary crude protein for maximum growth and feed intake of yearling Tswana sheep fed millet stover, sorghum stover and buffel grass hay based TMR.

MATERIALS AND METHODS

Location of study

The study was carried out at Botswana University of Agriculture and Natural Resources smallstock kraals, Sebele, Gaborone, from April to July 2010. This site is situated (25.94^{o} S, 24.58^{o} E) at an altitude of 991 m, with mean annual rainfall of 500 mm and average monthly maximum temperatures of 28.6°C and minimum temperature of 12.8°C (Animal Production Research Unit, 2001).

Sheep management and diets

Fifty-four (54) Tswana sheep yearling castrates (28.62 ± 0.25 kg of body weight) were purchased from different farmers from the south eastern part of the Botswana and ear-tagged. The animals were dipped using Flumethrin 1% m/v pour on acaricide (Drastic Deadline™, Bayer ® Animal Health, South Africa) and vaccinated against pulpy kidney and pasteurella diseases (Pulpy Kidney and Smallstock Pasteurella vaccines, Onderstepoort Biological Products company, South Africa.) on their first and second days of arrival respectively. The sheep were dewormed using Ivermectin 1 % (Ecomenctin®, Intervet, South Africa) on the second week of their arrival. They were then dewormed again with albendazole 1.9 % (Valbazen®, Pfizer, South Africa) after seven days. The experimental design was a 3 x 3 factorial in a completely randomized design (CRD), with nine treatments and six animals used per treatment as replicates. The animals were then allocated to individual pens of 1.5 m x 1 m concrete floored, roofed with corrugated iron and naturally ventilated (with half walls). Animals were randomly allocated to each treatment and were then adapted for fourteen (14) days to the pens and the experimental diets.

The main forages investigated were buffel grass hay, millet stover and sorghum stover at different crude protein levels (13.5 %, 15.5 % and 17.5 %) in total mixed rations. The ingredients and chemical composition of the experimental diets are shown in Table 1.

Table 1. Ingredients and chemical composition of experimental diets

Item	Treatments (Forage and CP level)								
	B1	S1	M1	B2	S2	M2	B3	S3	M3
Ingredients (% of DM)									
Buffel grass	30.00	-	-	30.00	-	-	30.00	-	-
Sorghum stover	-	30.00	-	-	30.00	-	-	30.00	-
Millet stover	-	-	30.00	-	-	30.00	-	-	30.00
Sunflower cake	24.30	26.45	27.33	36.50	39.48	39.48	48.57	51.60	51.6
Sorghum bran	38.95	36.80	35.92	26.75	23.77	23.77	14.68	11.65	11.65
Molasses	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
DCP	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Iodised salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Vit/mineral premix	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Chemical composition (% of DM)									
CP	13.50	13.50	13.50	15.50	15.50	15.50	17.50	17.50	17.50
NDF	27.45	27.81	28.71	30.53	31.11	31.78	33.59	34.17	34.85
ADF	17.36	17.57	18.17	19.50	19.87	20.31	21.63	22.00	22.44
ADL	2.15	2.59	3.08	2.26	2.70	3.18	2.36	2.81	3.29
Ca	0.62	0.58	0.53	0.57	0.53	0.49	0.52	0.49	0.44
P	0.39	0.37	0.34	0.36	0.33	0.30	0.32	0.27	0.26

B-buffel grass; S-sorghum stover; M-millet stover; DM –dry matter; CP-crude protein; NDF – neutral detergent fibre; ADF –acid detergent fibre; ADL – acid detergent fibre; Ca- calcium; P- phosphorus; Dicalcium Phosphate = DCP; 1 = 13.5 % CP; 2 = 15.5 % CP; 3 = 17.5 % CP

The experimental period was ninety days, and during that time the animals were fed TMR (Table 1) *ad-libitum* at the rate of 3% body weight (on a dry matter basis) daily in the morning at 0800 hrs after collecting and weighing the leftovers (refusals) of the previous day. The feed intake was calculated as the difference between the amount of feed offered and feed refusal. They were offered portable drinking water free choice daily. The animals were weighed every two (2) weeks in the morning before watering and feeding to determine their gains. All weights (feed and animal) were measured with the CFW 150 electronic weigh scale (±20g, Adam Equipment 2006 - Software version V1.04).

Diets chemical Analysis

Feed samples were collected and oven-dried at 65°C for 72 hours and ground to pass through a one millimeter sieve. The crude protein content was determined according to the procedures of Kjeldahl method (method 984.13, AOAC, 1996). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were analysed using ANKOM ^{2000} Fibre Analyzer and ADF residues were burnt to ashes to determine percentage of ADL according to Van Soest *et al*. (1991). Calcium was measured using Inductively Coupled Plasma/Optical Emission Spectroscopy (Model Optima™ 2100 DV, Perkin Elmer® precisely, Germany) while Phosphorus (P) was determined using UV- Vis Spectrophotometer (Model UV – 1601, Shimadzu Corporation, Japan).

Statistical Analysis

The data for feed intake and weight gain of sheep fed crop residues were analysed [Statistical Analysis System (SAS), SAS Institute Inc. 2004] using General Linear Model Procedure according to a 3 x 3 factorial arrangement with forage type and crude protein as the main effects in a Completely Randomized Design. The initial live-weight was included as a covariate for analysis of feed intake and weight gains. In case of significant difference ($P < 0.05$) among treatment means, Duncan's Multiple Range test was used to separate the means.

RESULTS AND DISCUSSION

The main treatments effects (Forage type and protein level) were responsible ($P<0.05$) for the differences in final weight, total weight gain, feed intake and average daily weight gains amongst yearling Tswana sheep. However, there were no significant interactions ($p > 0.05$) between forage type and protein levels on all measured parameters in yearlings. Total mixed rations (TMRs) that had millet stover produced higher ($P < 0.05$) feed intake, average daily gain (ADG), feed efficiency (FE), total gain and final weight in yearling sheep than those that contained sorghum stover (Table 2).

Table 2. Effects of forage type and crude protein level in total mixed ration on body weight gain and dry matter intake of yearling Tswana sheep.

Chemical composition	Initial-weight	Final Weight	Total gain (kg)	ADG (g/day)	TDMI (kg)	Feed Efficiency
1. Forage Type						
Buffel	28.58[a]	33.85[ab]	5.26[ab]	58.42[ab]	92.90[b]	0.38[ab]
Millet	28.65[a]	35.26[a]	6.61[a]	73.41[a]	102.66[a]	0.45[a]
Sorghum	28.60[a]	32.59[b]	3.99[b]	44.34[b]	88.63[b]	0.29[b]
2. Protein level						
13.50%	28.54[a]	35.22[a]	6.69[a]	74.32[a]	100.05[a]	0.46[a]
15.50%	28.67[a]	34.39[a]	5.72[a]	63.50[a]	94.97[ab]	0.41[a]
17.50%	28.62[a]	32.07[b]	3.45[b]	38.35[b]	89.17[b]	0.26[b]
3.Forage Type*Protein level interaction						
Mean	28.61	33.896	5.285	58.722	94.728	0.0556
Standard errors of the mean						
1	1.22	1.43	0.67	7.50	3.32	0.007
2	1.22	1.43	0.68	7.50	3.32	0.007
3	2.12	2.47	1.17	12.99	5.75	0.012
Probability						
1	0.999	0.034	0.031	0.031	0.014	0.146
2	0.997	0.005	0.005	0.005	0.079	0.025
3	1.000	0.983	0.982	0.982	0.937	0.951

Main effects are forage type (1) and protein level (2); Interaction between forage type and protein level (3); ADG-average daily gain; TDMI- total dry matter intake; kg = kilograms

[a,b,c]Values with different supercripts within same column within main effects are significantly (P < 0.05) different

The forages used in this study produced total dry matter intake that ranged from 88.63kg (sorghum stover) to 102.66 kg (millet stover), and daily dry matter intakes between 984.78 g (sorghum stover) to 1140.67 g (millet stover). Yearling sheep fed millet stover rations had higher (P<0.05) total dry matter intake compared to those fed diets containing

buffel grass and sorghum stover. Dry matter intake of forage based diets is related to the level of physically effective Neutral Detergent Fibre (peNDF) it contains (Mertens, 1997; Zhao *et al.,* 2011). This may suggest that even though the forages used in this study were processed through a similar method (chaffed by hammer mill through 1.5 cm sieve) and had relatively similar amount of different fibre components (NDF, ADF and ADL) as shown by Table 1, the fibre contained in the tested forages may have produced different ratios of particles size. This may have resulted in different levels of peNDF in different forage diets. Zhao *et al.* (2011) found that diets containing low dietary peNDF had high dietary intake, while Cooper *et al.* (1996) observed that sheep voluntarily selected long forage particles in their diets. This may suggest that millet stover diets had relatively longer forages particles compared to other investigated forages. The suspected longer particles size may have resulted in high rumination and chewing time amongst the yearling sheep and thus high saliva production that buffered the rumen. This ruminal environment favours multiplication and activity of cellulolytic microbes, and high numbers of these microbes increase digestibility of the ingested fibre and rate of passage (Church, 1988). The increased rate of passage increases the feed intake and supply of high microbial protein to the small intestines for absorption and utilization (Van Soest, 1994). This could explain the high feed efficiency in yearling sheep fed millet stover based rations in this study.

The results of feed intake in this study were in contrast to those obtained by Singh *et al.* (2011) who found significantly higher intake in sorghum stover than millet stover fed to sheep rams. Despite this, Singh *et al.* (2011) observed higher final weights in animal fed millet stover than in those fed sorghum stover, which is in agreement with the findings of this study. The high millet stover intake in this study was more efficiently utilised (0.45) than sorghum stover based diets (0.29), hence high ADG and total gains. The daily gain range of 20.43 to 88.15 g/day found in this study was higher than the 14 to 23 g/day of Ethiopian Highland yearling lambs fed finger millet straw with different protein sources (Noug seed cake, cottonseed cake and urea) mixed with wheat bran (Alem *et al*. 2011). However, the range of ADG in this study was lower than 92.6 to 120 g/day of Tswana yearling sheep fed diets (buffel grass, veldt grass,

sorghum forage and millet forage) having 40 % *Lablab purpureus* L. as a protein supplement (Aganga and Autlwetse, 2000).

This study produced total dry matter intakes that ranged from 32.07 kg to 35.22 kg. The feed intake of yearling Tswana sheep was significantly influenced ($P < 0.05$) by the level of crude protein in TMR. On average sheep fed diets with low CP (13.50 %) had the highest total dry matter intake (1000.05kg) and average daily intake of while those fed rations with 17.50 % CP had the lowest dry intake (891.17 kg). The information on the effect of different crude protein levels on feed intake of yearling Tswana sheep was scant. However, the trend of these results was similar to that found in works by Yuangklang *et al.* (2010) and Allen (2000) on adult ruminants, and this was attributed to the high satiation effect of protein (Allen, 2000). Forbes (1995) pointed out that feeding excessive protein leads to slower flow rate of feed in the intestines, and high heat production from deamination, effects which eventually depress feed intake.

The average daily weight gain and final weight of the yearling Tswana sheep were influenced significantly by the level of crude protein in their diets. The sheep feeding on rations containing low crude protein level (13.50 %) had the highest daily gain of 74.32 g/day followed by sheep feeding on rations containing 15.50 % CP (63.50 g/day) and 17.50 % CP (37.92 g/day). It was also noted that high daily weight gains were found in yearling sheep that had high daily feed intake, and low daily feed intake produced low daily gains. Van Soest (1994) pointed out that high feed intake promotes both escape protein and increase microbial protein synthesis in the rumen. Microbial protein synthesis in the rumen accounts for 50 to 80 % of total absorbable protein (Stern *et al*., 2006), and this could mean that microbial protein is more likely to influence daily gains in ruminants than bypass protein. The high average daily weight gain observed in low protein level was in contrast to the findings by Chumpawadee *et al.* (2009) and Hwangbo *et al.* (2009) in their researches on yearling heifers and growing goats respectively, who found significantly higher weight gain with high protein diets. On the other hand, Machado da Rocha *et al.* (2004) found no significantly difference amongst treatments containing 12, 16, 18 and 20 % CP in average daily gains in Santa Ines lambs. When deciding on which level of dietary

protein was optimum for rumen fermentation in sheep wethers, Veira and Ivan (1982) found that there was wastage of dietary protein at levels greater than 11.1 %. Apart from wastage through excretion and ammonia production, synthesis of microbial protein under high protein diets is restricted by availability of energy (Van Soest, 1994; Buxton, 1996). This could suggest that addition of extra amount of digestible carbohydrate to high protein diet (17.5 % CP) could have improved microbial population and utilization of excess ammonia in the rumen and thus improved daily weight gain in 17.50 % CP diets.

CONCLUSION

Feeding millet stover, sorghum stover or buffel grass based total mixed ration at 13.5 % crude protein to Tswana yearling sheep improved feed intake and weight gains. Feeding high crude protein diets to yearling sheep will be wasteful since these sheep cannot efficiently utilize high protein feed. Yearling Tswana sheep fed millet stover based rations had higher feed intake and weight gain followed by sorghum stover and buffel grass hay based rations.

RECOMMENDATIONS

An investigation to determine the amount of nitrogen loss in yearling Tswana sheep fed diets of the similar crude protein levels and forages used in this study is recommended. It is also important to evaluate levels of peNDF in the tested forages and relate those levels of peNDF with dry matter feed intake of forages on yearling Tswana sheep.

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